World Ocean Circulation Experiment

NEWSLETTER

Number 7 March 1989

FEATURES

THE INTERNATIONAL WOCE SCIENTIFIC CONFERENCE

This issue of **the** WOCE newsletter focusses on the report of the International WOCE Scientific Conference which was held at UNESCO House in Paris, 28 November - 2 December. The principal document for discussion at the conference was the WOCE Implementation Plan, which was described in Newsletter No 6 and is now published by the World Climate Research Programme in two volumes as WCRP 11 and 12.

The conference was attended by 175 participants from 42 nations and provided the first opportunity to present WOCE to a wide international gathering and to assess the extent of the resources that the international community is willing to commit for its implementation. It was agreed that in general the proposed resources were sufficient so that the field programme could be started with confidence as planned in 1990. Of course, resources for certain elements of WOCE were not committed at this initial opportunity.

During 1989, the WOCE planning and implementation structure, that is, the Core Project Working Groups and the operational Planning Committees, as well as the SSG itself, will be considering the implications of the conference for WOCE and the adjustments that will need to be made to effectively carry out the programme. This process has already started.

This Newsletter reproduces in slightly reduced form the report of the Conference which will soon be published. The conclusions and recommendations are however complete. Omitted are the sections that discuss the future organization of WOCE and its relationships with the parent government and intergovernmental bodies. The conference did however produce a basis for improving these relationships to the benefit of all concerned with the success of WOCE and the ability to predict climate change. Also omitted are appendices detailing commitments from national organizations and summaries of these commitments.

OPENING SESSIONS

The International Scientific Conference for the World Ocean Circulation Experiment was sponsored by the four parent organizations. On the non-governmental side, these are the International Council of Scientific Unions (ICSU) and the Scientific Committee on Oceanic Research (SCOR); on the intergovernmental side, the Intergovernmental Oceanographic Commission (IOC) and the World Meteorological Organization (WMO). The Organizing Committee for the conference had been established by the WOCE Scientific Steering Group and was chaired by Professor C. Wunsch, Chairman of the WOCE Scientific Steering Group.

The Chairman, Professor G. Siedler, noted that WOCE is a component of the World Climate Research Programme (WCRP) and that the degree to which climate can be predicted, and the extent of man's influence on climate, is not just an esoteric matter. If the activities of mankind lead to sea level changes of only a few decimetres, there **will** be implications for living conditions and the economics in many countries. **Fu**rther, if climate predictions force us to reduce the output rate of carbon dioxide, the necessary decrease of energy consumption will have considerable consequences for energy consuming and energy supplying countries and industries. The important climatic changes are large-scale global phenomena which have implications for people around the world, and they must be investigated on a global scale. Prediction of these changes is the basis of WOCE.

Professor Siedler noted that the fundamental ideas of WOCE had been developed by groups of scientists who saw

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that the time was right for a major international endeavour to investigate the ocean's role in the climate system. Such an experiment can only be done with the full co-operation and expertise of the scientific community, with the support of national agencies, and with the involvement of governments in certain aspects of the programme. A main goal of the conference was to bring these communities together and to convince the participants that WOCE is an important step towards the long-term goal of predicting climate change as well as an exciting oceanographic experiment in itself and an ambitious but feasible experiment based on reasonable ideas for its implementation and organization.

A second goal of the conference was to provide the participants with the opportunity to identify the potential contributions to WOCE that can be expected from the various institutions and national organizations, with respect to scientific and technical manpower, ships, computing facilities, instruments, etc. as well as critical gaps that may exist in these resources.

The conference was attended by a good mix of participants from scientific institutions, agencies, governments and intergovernmental organizations. About 175 participants from 44 countries registered. This was a remarkable number of countries showing interest in WOCE and showed the international scope of the programme and the interaction of the various communities.

During the opening sessions Dr Sorin Dumitrescu, Acting Assistant Director General for Science of Unesco; Dr Julia Marton-Lefebre, Deputy Executive Secretary of ICSU; Dr Pierre Morel, Director of the WCRP representing WMO; Professor Ulf Lie, Chairman of IOC; and Professor Gerold Siedler, as Past-President of SCOR, addressed the conference. A keynote address for the purpose of putting WOCE into context, both historically and with respect to other international programmes, which had been prepared by Dr R.W. Stewart who was unable to attend due to illness, was read by Dr R. Chesselet.

The WOCE Implementation Plan was the principal document for the conference, and was introduced by Dr G. Needler, the Director of the WOCE International Planning Office. He described the procedures which had been followed in developing the WOCE Scientific Plan, published in 1986, as well as the Implementation Plan, published four months before the Conference, and how they had received broad input and review from the international scientific community. He also discussed the nature of the Plan and how it could be used by the conference in assessing the level of resources available for WOCE.

Dr A. McEwan, chairman of the Committee on Climatic Changes and the Ocean (CCCO), also addressed the conference and discussed WOCE in the context of the increasing public concern over climate change. He also noted the problems of obtaining support for a massive scientific experiment such as WOCE from governments, institutions and individuals that may have other priorities or difficulty in participating within the international/intergovernmental structures that were being proposed.

PRESENTATION OF THE WOCE PROGRAMME

The Scientific Programme of WOCE was introduced in a series of talks led by the Chairman of the SSG, Professor C. Wunsch, who presented an overview.

He pointed out that by the middle of the 1970s the oceanographic community had come to appreciate several features of their field: recognition of the global character and turbulent nature of ocean circulation; increasingly urgent questions about climate change, sea level rise, fisheries instability, etc.; strong suggestions of the possibly dominant role in climate of oceanic heat fluxes; extreme El Niño events as a non-subtle demonstration of the impact of ocean/atmosphere interactions, suggesting the strong possibility of other, less obvious interactions controlling climate.

Around 1980, it seemed reasonable to consider actually confronting these problems. There was increasing national and international concern over climate instability and the WCRP was formed. For the first time, the meteorological community seemed prepared to admit the fundamental importance of the ocean in climate dynamics. The oceanographic community itself had a much increased understanding of oceanic sampling issues and oceanic dynamics and these issues could be addressed observationally, for the first time, through the technological progress of the preceding decades.

In formulating a global experiment, it is necessary to recognize that it is very difficult, for a variety of reasons:

- There are no operational government agencies for ocean observations and governments rarely can deal with problems of duration exceeding the time to the next election. Observing the ocean is intrinsically very difficult (opacity to electromagnetic radiation; corrosive effects; high pressures; rapid time dependent changes; it is almost unimaginably large).
- The traditions of the oceanographic community are in conflict with sustaining large-scale organized programmes over many years and the community is itself quite small.

Recognizing these problems the SSG had employed several principles in constructing a practical Implementation Plan. Of central importance is the assumption that one must define the basic physical state as a prerequisite to true understanding of the dynamics and the biochemical state. It is essential that the experiment remain clearly scientific - it would be a major error to construct operational systems prematurely, especially given that few of the observational tools are operational but are still developmental. No single observational system can address all important problems for technical, logistic, scientific and economic reasons and the foundation for the implementation of WOCE must be existing laboratories, governmental and intergovernmental organizations.

For practical reasons, the SSG had divided the Experiment into three overlapping Core Projects. A somewhat simplified view of Core Projects 1 and 2 is that they are intended to define the basic thermodynamical/ chemical state of the ocean as it exists in the early 1990s, including the definition of important dynamical scales of temperature, salinity, oxygen, nutrients and CO_2 and the dominant connections to the atmosphere: surface stress, heat flux and fresh water flux. A peculiarity of ocean dynamics is that the definition of the thermodynamical state and forcing produces accurate estimates of property fluxes and divergence (e.g. heat, mass, water vapour, nutrients,…).

Core Project 3 is intended to isolate and understand through focussed regional and basin-scale experiments small-scale physics critical to modelling of global scale circulation/climate.

The three Core Projects are directed at the first Goal of WOCE. The intention of the second Goal is to leave in place a sufficient observational base to determine longer term oceanic changes (producing determination of the 'representativeness' of WOCE observations). By the time WOCE is all over, it is aimed to have, on a global basis:

- synoptic daily wind fields,
- daily maps of sea surface elevation, both the absolute and time-dependent parts,
- dense, near mesoscale resolution hydrography, oxygen, nutrients, chlorofluoromethanes, tritium and helium-3, defining the basic oceanic thermodynamical/chemical state and hence the major interior fluxes, sources/sinks of these properties,
- a global, "transparent-to-the-user" data exchange and inventory system,
- basin-scale, eddy-resolving general circulation models with active thermodynamics and bio-chemical cycles; global-scale, dynamically and thermodynamically constrained circulation models with biochemical cycles,
- global interior and boundary region direct measurements of flow fields by floats over a five year period,
- mass/property transports and interannual fluctuations of all deep boundary currents,
- quantitative, global estimates of heat, fresh water, nutrient fluxes within the ocean and to and from the atmosphere,
- an observation system that can be left in place, economically, to be used in conjunction with future regional programmes and continued ocean-climate studies,
- much improved existing tools (water samplers, CTDs, telemetry, analytical techniques, data/model combination methods, float systems, satellite sensors),
- an international organization capable of continued operation of a global oceanographic system.

The grand result is to be much improved understanding of the general circulation, its consequences, its potential changes and implications for climate.

Professor Wunsch stated that to carry out WOCE is going to be difficult but that the Implementation Plan is technically and financially feasible. The scientific judgement was that after WOCE we will be far closer to understanding the oceanic role in climate than we are now. The Plan addresses problems which are, and will remain, extremely important, with enormous economic consequences (climate change, sea level rise, agricultural and fisheries changes, policy implications for fossil fuel burning, nuclear power, etc., etc.). WOCE addresses critical societal problems, through the mechanism of an exciting scientific programme.

After Professor Wunsch's overview, the programmes of each of the three Core Projects of WOCE and the Numerical Modelling Programme were presented by the Working Group Chairmen, as well as the programme for obtaining the large-scale forcing fields by the Chairman of the JSC/CCCO Working Group on Air-Sea Fluxes. The second day of the conference was opened by nine presentations describing the Observing and Data Management Systems for WOCE.

STATEMENTS BY INSTITUTIONS AND NATIONAL ORGANIZATIONS

As a step towards assessing the scope of possible participation in the WOCE field programme, talks expressing interest were given by representatives of institutions and national organizations. In all, 31 talks were given. An attempt was made to find out how smaller countries can take part in a way which leads to contributions to the global programme while the oceanographic communities in these countries are acquiring additional knowledge about regions of their interest and gaining experience with new technology.

General support of WOCE was expressed by those participating in this part of the programme. In a number of cases those speaking indicated in some detail the nature of contributions to be made to WOCE or outlined the content of a programme. Most referred explicitly to various components of the Implementation Plan. Other speakers, while supporting WOCE in principle, indicated the intention to develop a specific contribution in the future, in some instances with the need to co-operate with other nations in fulfilling the specific requirements given in the Implementation Plan. The detailed information provided (summarized in Table 1, see page 10) formed the basis for the assessment of resources for WOCE which followed in working groups.

ASSESSMENT OF RESOURCES BY OBSERVATIONAL PROGRAMMES

1 Introduction

After the presentation of the WOCE programme and statements of interest, the meeting was divided into working groups to address the availability of resources for various elements of the WOCE field programme. The working groups addressed: direct current measurements, including floats and moored instruments; the surface layer, including the VOS programme; surface drifters; flux measurements and surface meteorology; satellites and sea-level for altimetric purposes; the WOCE Hydrographic Programme; and Data Management. Each working group made a detailed listing of the resources that could be identified as available for WOCE. The working groups also made general statements regarding the observational programme and provided a number of recommendations for its improvement or to ensure its implementation. A summary of their conclusions is as follows.

2 The Hydrographic Programme

The Working Group on the WOCE Hydrographic Programme (WHP) was well attended and chaired by Professor L. Merlivat. Dr T. Joyce, chairman of the WHP Planning Committee, reviewed the rationale for the WHP within WOCE, the design criteria for the WHP sampling programme and the standards and precisions requested for the WHP.

The Working Group assessed the resources available for WOCE and found that more than 70% of the WHP ship-time requirements (see Figure 1) were covered. Some indications of additional ship-time availability were noted, although they were given in a general context. Clarification was obtained where more than one participant indicated an interest in the same section and some modifications were made during the session. Supplementary support was also noted where indicated.

In general the Working Group concluded that the WHP plans as presented in the Implementation Plan, the requirements and the general structure for running the programme were very adequate and promised wide acceptance by the oceanographic community. It was also very favourably noted that the structure for co-ordination of these efforts and for maintaining close collaboration between participants in the WHP guaranteed wide participation. The proposal for a co-ordinating Project Office for the WHP, which would partially fulfil the needs of a Data Assembly Centre, and for a devoted Special Analysis Centre also met with wide approval.

The following four conclusions were also agreed:

1. The Working Group recognized that different methods for analysis of water samples and data may satisfy WHP requirements for accuracy and precision and that there is no intent to establish only one method for measurement for the WHP as long as different approaches yield results that meet WHP standards.
2. The Working Group discussion accented the need to utilize existing international arrangements, for example the IHO and the SCOR/WG 77 (Laboratory Tests Related to Basic Physical Measurements at Sea), which can facilitate the accomplishment of the goals of the WHP.
3. The Working Group stressed the importance of continuation of the IAPSO Standard Seawater Service (IOSDL, Wormley) for calibration of WHP salinometers and safeguard of quality standards.
4. WHP resources, while apparently going far towards achieving nearly a complete coverage in the one-time survey, need to be carefully evaluated and managed in order to insure a complete suite of measurements to WHP standards.

3 Direct Current Measurements

The Working Group addressing the direct current measurements by instruments and deep floats was convened by Dr J. Elliott.

Moorings

The Working Group concluded that in general, the planned moored instrument programme had widespread support. Interest in specific moorings ranged from firm plans to potential participation from laboratories which have not yet sorted out their priorities. Although some gaps are apparent, particularly in the Southern Ocean, the indication was that the overall mooring programme is viable (see Figure 2).

Clearly however there were not enough resources identified to cover all the requirements in the plan. The working group concluded that consideration needs to be given to a reassessment of priorities in the light of currently expressed interests. Some moorings, for which interest has been confirmed, did not meet the intended purpose when not complemented by other measurements as required in the Plan. In such cases it might make more sense to redirect resources toward completing some lines by abandoning those only partially subscribed.

Indications were that laboratories in various countries will provide moorings for the western part of all the heat flux lines except for the Indian Ocean, which was considered a high priority. There was a lesser interest in the eastern moorings and the question was raised as to their importance.

The thermistor/salinity moorings generated little interest and the group wondered what stimulated their inclusion in the requirements.

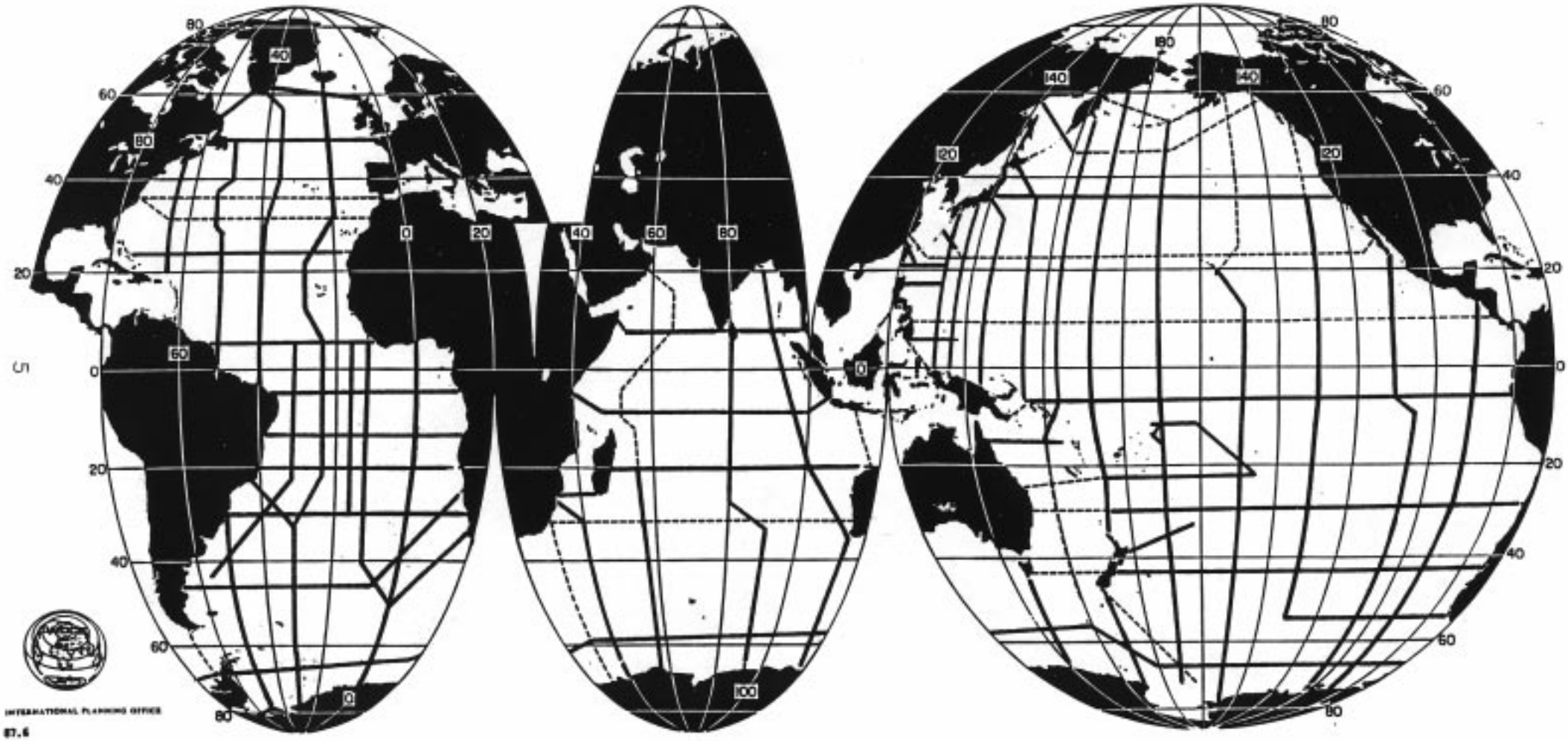

Figure 1. The WOCE One-time Global Survey

——— Tentative commitment

- - - - - - - - - No known commitment (as of February 1989)

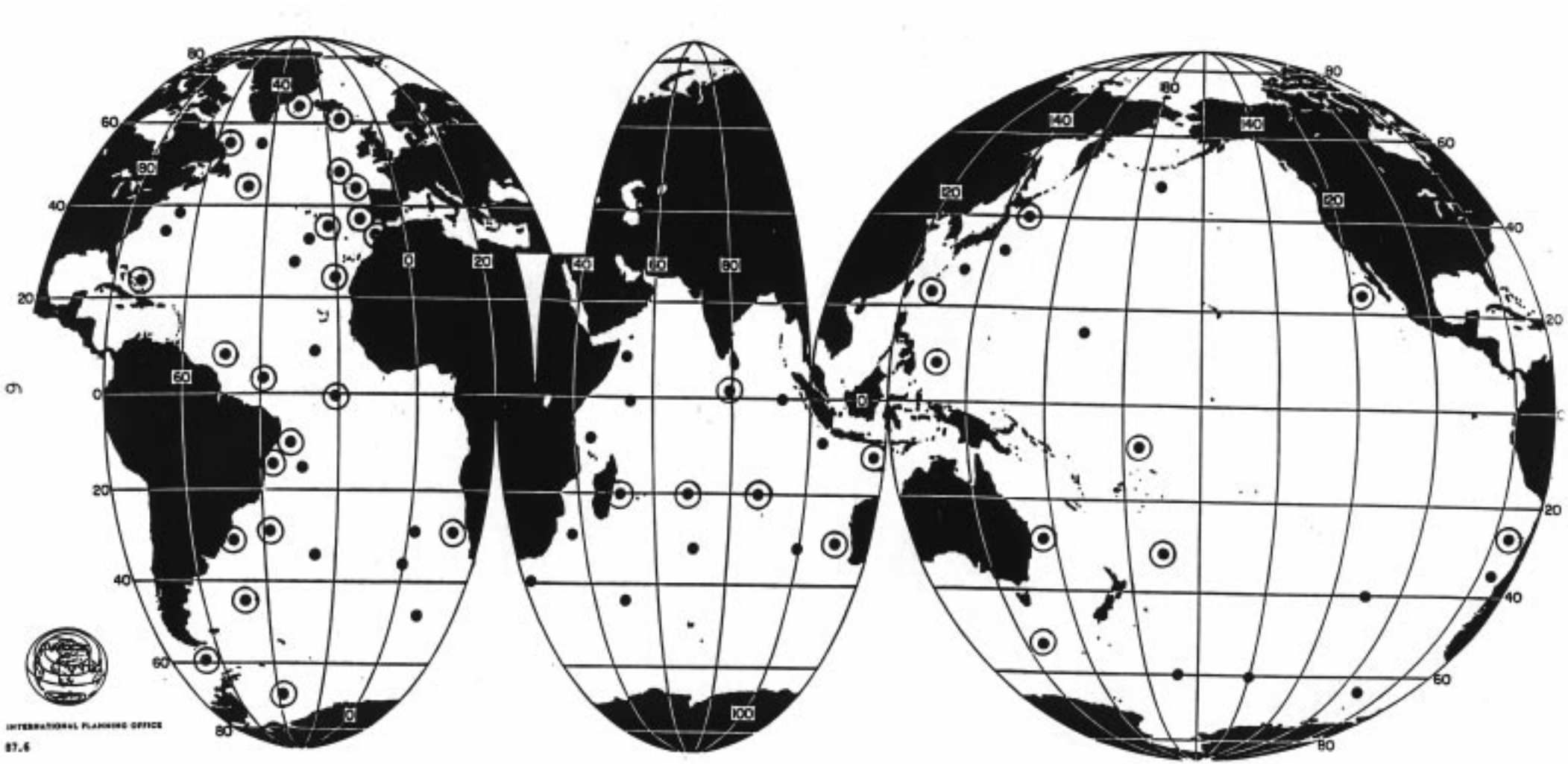

Figure 2. Current Meter Moorings

- • No known commitment
- ⊙ Tentative commitment

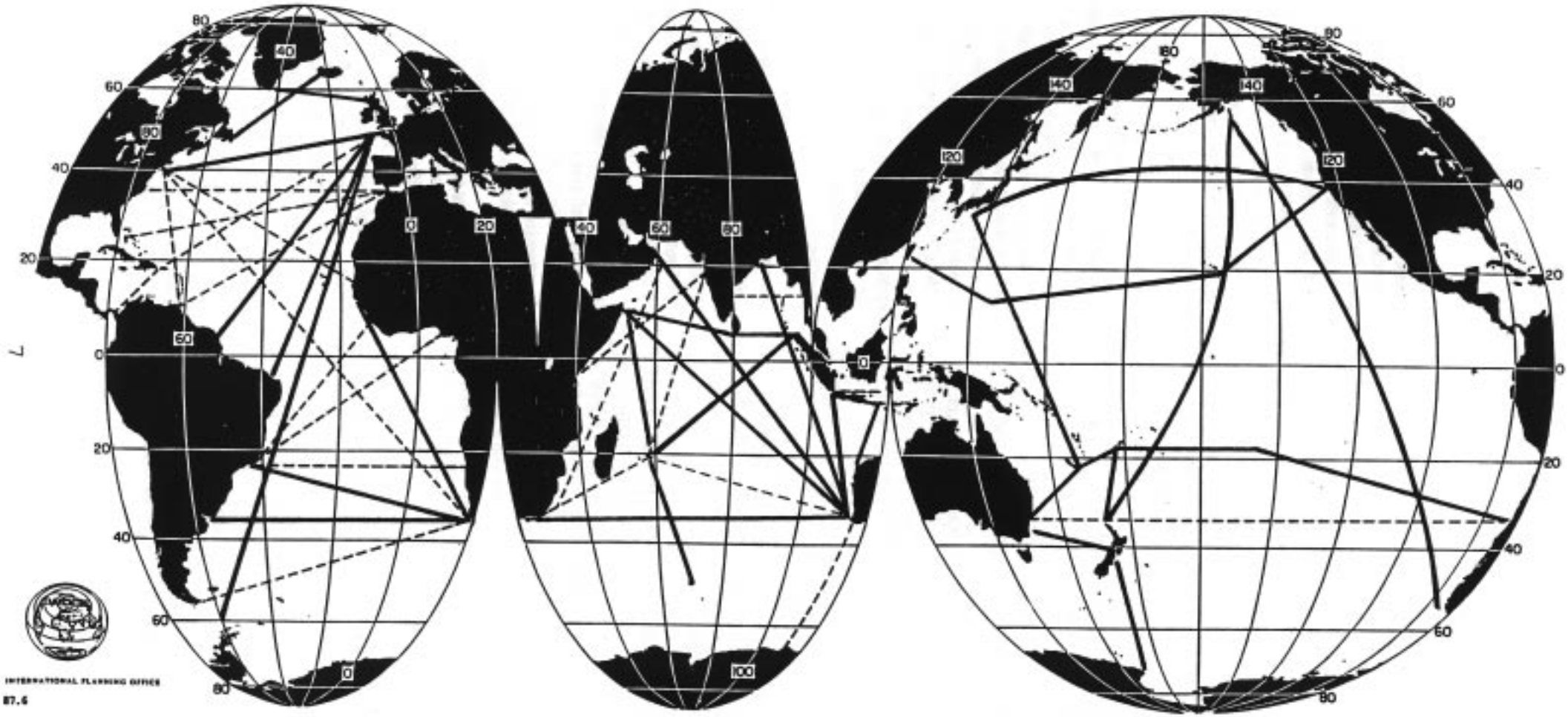

Figure 3. WOCE XBT/XCTD Special Requirements

——— Tentative commitment and/or provided via TOGA/IGOSS

– – – – – No known commitment (as of February 1989)

For the spreading of Antarctic Bottom Water it seemed that the Southern Ocean moorings were located close enough to be merged with the three Indian Ocean mooring arrays to meet all goals.

The Core Project 2 eddy statistics moorings, considered vital by the Group, attracted insufficient interest.

The Float Programme

Institutions from Japan, the US and France indicated firm intentions to commit resources to the Float Programme. There is indication that institutions in FRG hope to develop a capability starting with experiments at the Mediterranean outflow and later in the South Atlantic.

The US expects to deploy 1100 floats in the global programme. They also expect to provide 400 acoustically tracked floats for the Surface Layer, Deliberate Tracer Release and Deep Basin Experiments. They hope to provide some additional floats for enhanced resolution in the tropics, particularly in the Atlantic.

The Group concluded that there was adequate commitment to the global float programme which would also provide for an Atlantic enhancement in the tropics. No interest was identified for certain special requirements specified in the Implementation Plan.

Experiments are being currently conducted in Japan with short-ranging 600 km equipment but there is hope that RAFOS floats will be available during WOCE. Between 20 to 40 floats is a possibility and they will be deployed in the western Pacific although with adequate sound source availability in the area, consideration would be given to deploying them in the Antarctic.

Two French projects are under consideration. Of first priority are measurements in the Core Project 1 South Atlantic gyre (extending to 10°N) with 100 floats primarily at one level (1000 metres). The second priority is the Antarctic Circumpolar Current with a three-year experiment using 90 floats also at the 1000 metre depth.

4 The Surface Layer

The Working Group addressing surface layer measurements was chaired by Dr R. Pollard.

The VOS Programme

In the Atlantic (see Figure 3), firm commitments have not yet been made for a large number of XBT lines, but the US-NOAA stated that they expected to greatly expand VOS activity.

In the Pacific Ocean all the high-resolution lines proposed were subscribed.

In the Indian Ocean, where WOCE and TOGA requirements are nearly identical, it was recognized that progress is being made towards implementing about half of the TOGA lines, but that WOCE support would be necessary to fully implement the network.

Salinity is a useful parameter in view of the difficulty of making precipitation and evaporation measurements over the ocean. However, use of the current XCTDs might not be practicable in the VOS programme, because of the requirement for use at speeds less than 10 knots. The suggestion was made that salinity samples could be drawn from water intakes for analysis ashore.

The need for all VOS and research ship operators to improve the quality of surface meteorological observations and the frequency of reporting was noted. Where possible, automatic meteorological systems should be installed.

The Drifter Programme

After reviewing the technical feasibility of surface drifters and potential improvements, the Working Group concluded that the proposed strategy for WOCE was appropriate.

Although the present level of commitment (~50%) was low, further commitments depending on technical developments and subsequent pricing levels seem to be imminent and the present short-falls could be covered in the run-up to the Intensive Observation Period. The need to co-ordinate efforts with existing and planned drifter programmes outside WOCE, e.g. TOGA, was stressed as was the need for a uniform approach in design, deployment and data processing to achieve the best possible results of uniform quality with the widest possible participation of all parties interested in the programme.

The technical feasibility of attaching surface pressure sensors to current drifters was discussed. The general consensus within the Working Group was that atmospheric pressure measurements would be of considerable value to WOCE, particularly in data sparse (non-tropical, especially in the Southern Hemisphere) regions and a programme should be initiated to design, test, and deploy such drifters.

It was felt that fully tested, operational pressure enhancements could be available within two years, that a new generation of small current measuring drogued buoys with pressure sensors could be available that would be cheaper than present meteorological pressure buoys by about a factor of two, and that their use by meteorological agencies should be attractive and of great mutual benefit to both meteorologists and oceanographers.

5 Satellite Systems

A large fraction of the world's oceanographic resources will be committed during the decade of the nineties to the WOCE programme. This commitment is forthcoming on the understanding that ocean satellites will provide important data on the sea surface topography and the coupling between the ocean and the atmosphere essential for the understanding of the dynamics of the ocean circulation and the role of the oceans in climate. This requires a serious commitment by space agencies to ensure continuous, global data of the ocean surface from satellites.

The Working Group on Satellite Systems chaired by Dr P. Woodworth recommended that, in view of the importance of ERS-1 to WOCE, the importance of ERS-2 as a back-up

needed to be stressed in the event that ERS-1 is launched unsuccessfully or that its altimeter, and particularly its scatterometer, systems fail early in the mission. A back-up ERS-2 should be available for launch as soon as possible consistent with a 3 year overlap of its operations with WOCE. It was noted that TOPEX/POSEIDON will have no possibility of back-up.

In addition, since the construction of an ERS-2 is necessary as an ERS-1 back-up, in the event that ERS-1 operates successfully, ERS-2 should be launched subsequent to it in order to continue the altimetric and scatterometric time series. ERS-2 would fill the projected multi-year gap between ERS-1 and the launch of the first polar platform. The failure to establish a continuity between ERS-1 and the polar platform would represent a serious set-back to WOCE and the WCRP. Similarly, the possibility of the NASA NSCAT scatterometer being operated on the Japanese ADEOS satellite in the mid-1990s was strongly endorsed.

The importance to WOCE of a suitable orbit for ERS-1 and its back-up was also noted. The WOCE SSG had already requested a 17-day repeat for the majority of the ERS-1 mission and with one cycle of 350-day repeat.

WOCE requires a dedicated gravity mission before or during the mid-1990s and it was encouraging that ESA plans a mission (Aristoteles) with this objective.

In view of the importance of drifters, pop-ups, submersible robots, etc. in WOCE and future projects, satellite data acquisition systems such as those which follow-on from Argos should be technically matched to the requirements of the *in-situ* devices, and *vice-versa.*

The provision of tide gauge data for altimeter orbit calibration and tidal constants (for altimetric tide model constraints) seemed to be in need of review from the viewpoint of WOCE. In addition, if locally possible, tide gauge bench-marks should be geocentrically located regularly by modem geodetic methods (GPS etc.). Ideally, regular absolute gravity measurements should also be made near to the tide gauge sites. These data, together with altimetry, would allow the long-term fixing of the ocean surface within the same reference frame (IERS system).

Lastly, the necessity for a firm commitment to altimetry, scatterometry and other forms of remote sensing (e.g. sea surface temperature measurements, sea-ice monitoring, water vapour content, even rainfall measurement if possible) into the next century was emphasized. The long lead time required for satellite systems imposes difficulties in optimum technical choices. If necessary, commitments should be made to future missions based on established technology in order to ensure continuity of measurements. The possibility of there being different future polar platforms for different purposes as presented by ESA to the conference, rather than the all-purpose platforms proposed previously, was welcomed.

6 Data Management

The Working Group, which was chaired by Dr E. Lindstrom, discussed potential contributions to WOCE and some general aspects of the WOCE Data Management Plan. In the latter category, the Working Group recognized the tremendous importance of the data-sharing policy as described in the Implementation Plan and recommended endorsement by the Conference. A summary of the commitments made to WOCE data management is given in Table 2.

Data Assembly Centres

Information was provided concerning an offer from some US institutions to perform quality control functions of a DAC for their WHP data and co-ordinated data distribution function by the FRG National Data Centre.

A US Global Drifter Centre will perform many of the functions of a Data Assembly Centre (DAC) but data distribution to the general WOCE community is to be performed by the MEDS of Canada. It was noted that a US TOGA Centre will also be generating weekly analyses and that MEDS acts on behalf of the WDC system as an international data source.

Because of the small number of investigators using subsurface floats there may not be a need for a formal DAC but there still was a requirement for a data management statement so that other WOCE scientists would know how, where, and when to obtain data.

1, 2, 3 or more centres could be available for subsurface thermal data. Clarification was needed on whether there will be a centralized distribution point as for TOGA or whether a more distributed system will be utilized. France tentatively offered to expand its TOGA Subsurface Thermal Data Centre for TOGA to include WOCE. The principals will need to decide on data flow.

The working group considered a DAC for current meter data is needed, but its functions could be distributed.

Although the present structure at the TOGA Sea Level Centre and the UK Marine Information and Advisory Service (MIAS) will need some adjustment to meet WOCE objectives, the basic structure of a DAC is in place. The system is already part of internationally recognized systems.

It was recognized that WOCE can only keep informed of existing plans for satellite data management, but that WOCE scientists will need easy access to data sets. How these data can be accessed by WOCE scientists needs to be defined. Satellite data products are generated by agencies outside the WOCE data management system, however analysis products from these data are essential to WOCE goals.

The Data Information Unit (DIU)

The US stated it would only continue its support for a prototype DIU (now called a Data Management Unit by the US) for approximately two more years. The need and support for a long-term international DIU needs to be considered. If this is not available, then other solutions for the functions performed by the DIU need to be found since data tracking and availability are key to a global international experiment such as WOCE.

Table 1: Major WOCE Resource Requirements and Tentative Commitments

Observational Element	Requirement	Tentative Commitments
One Time Survey	10.4 ship years	))21.5 ship years
Repeat Hydrography and Time Series	15.0 ship years	)
Subsurface Floats	ca 3500	ca 1900
Surface Drifters	ca 4000	ca 2000
Moorings	ca 350	ca 250
Sea Level Stations	40	>40 sites available, most upgrade to meet WOCE requirements
XBT standard (750 m)	5000/y (In addition to TOGA and IGOSS)	>16,5000 available but commitments are not entirely consistent with requirements, nor is TOGA data set complete
XBT deep (1000 m)	11500/y	
Altimetry/Scatterometry	Several satellite missions	ERS-1, 1991 TOPEX/POSEIDON, 1992 ERS-2, 1993 ADEOS, 1994 ARISTOTELES, 1994

Table 2: WOCE Data Management Facilities

Facility	Operator
Data Assembly Centers	
WHP	USA, WHP/PO and FRG/DOD
Upper Ocean Thermal	France
Surface Drifters	(Canada, MEDS)
Subsurface Floats	TBD
Moored Current Meters	USA
Sea Level - Rapid Delivery	USA, Univ. of Hawaii
Sea Level - Comprehensive	UK, MIAS/PSMSL
ADCP	TBD
Data Information Unit	USA, Univ. of Delaware (Thru 1990 only)
Special Analysis Centers	
WHP	FRG, DOD, MPI and IfMH

ASSESSMENT OF RESOURCES BY CORE PROJECTS

1 Introduction

Upon completion of the reviews of each observational component, the conference again divided, this time along Core Project lines to analyze whether the commitments of resources could meet the objectives of the Core Projects. In general, it was found that this was the case but a number of gaps and potential modifications for consideration by the Core Project Working Groups were noted. The findings and conclusions of the Working Groups follow:

2 Core Project 1

Atlantic Ocean: chaired by Dr A. Colin de Verdière

The one-time hydrographic survey misses contributions for the sections at 32°N and 36°N. The repeat survey lacks coverage of the section at 30°S and the array at the same latitude on the eastern side of the South Atlantic.

The proposed current meter mooring locations were fairly well subscribed with the exception of moorings for the exploration of eddy statistics in the South Atlantic and the control volumes in the North Atlantic.

The float programme should achieve the required 500 km resolution Core Project 1 coverage.

As additions to the present plan it was proposed that one additional section be occupied between Scotland-Iceland-Greenland to measure transports over the various ridges and that, because of the large variability, it be repeated.

Repeat hydrography and synoptic mooring work were proposed by the USSR in the Newfoundland Basin and in the tropics.

Some West African countries proposed enhancement of the WOCE programme in the eastern tropical Atlantic.

Pacific Ocean: chaired by Dr B. Taft

It was concluded that the one-time hydrographic survey lacked tracer measurements in the North Pacific.

The lack of suitable vessels at the right time and place, and the lack of adequate equipment needed for the large volume sampling (LVS) was seen as the principle reasons why scientists have not indicated sufficient commitments. Australian, New Zealand, and Chinese scientists indicated a desire to participate but lack full capability. Japan has a LVS capability but on some lines it may use ships that cannot manage large samplers. New Zealand can do tritium.

Canadian scientists, which have a LVS capability, offered to consider undertaking the eastern part of line P1 and the northern part of line P16 which had gone unclaimed.

There are evidently suitable platforms which, if properly manned and equipped, could be used to fill identified gaps and there is a plan to have a US-WHP team and equipment available for at least one 45-day cruise per year on a non-US vessel.

The USSR offered to undertake lines in the Sea of Okhotsk but it was not clear to what degree the full WHP requirements could be met.

A number of the Pacific sections were discussed regarding scientific rationale for their location and possible subscribers and a number of suggestions were forwarded to the Core Project 1 Working Group.

Peru indicated support for a 500 mile repeat (quarterly) hydrographic section off the coast of Peru. For some lines in the northeast Pacific, for which US scientists are considering a VOS solution, the repeat hydrography programme seemed to be in good shape with respect to platforms as long as agreement could be reached regarding frequency of repeat sampling.

The Group noted that according to presently available information several hydrographic time series stations were not going to be covered. Some possibilities of redressing this situation were proposed.

'The Group agreed that the Core Project 1 Working Group needs to reconsider mooring locations in the light of information provided at the Conference. Some gaps could be filled by proposed programmes should it be found they would be suitable to replace those given in the Implementation Plan.

Current indications are that the surface drifter requirements for the Pacific will be about 80% subscribed with contributions from Canada, Taiwan, Japan, the US and Australia. Other nations may increase this coverage.

The 12 high resolution Pacific VOS lines are all subscribed and it is anticipated that the low resolution Transpac and TOGA XBT surveys will continue through the WOCE period.

The combination of likely-to-be-available RAFOS and ALACE floats seemed to be just sufficient for the global programme. There may be a shortfall of floats in support of specific experiments which are still under review in the Pacific.

The basin-wide TOGA ATLAS array on the equator was identified as a source of critical surface flux data. The South Pacific was not considered to be adequately sampled and additional effort should be made to add voluntary observing ships in this region.

Indian Ocean: chaired by Dr M. Fieux

The Working Group reviewed the WHP, Special Survey Areas, the XBT Network, sea level and current meter moorings in the Indian Ocean. Each of the components were found to be lacking in one form or another, but the initial contributions identified indicate that Core Project 1 is viable in the Indian Ocean.

Only two WHP sections in the Indian Ocean were not subscribed. As in the Pacific, some suggestions were made as to modifications in the Implementation Plan for consideration by the Core Project 1 Working Group.

The Special Survey Areas, in which concentrated observational programmes are needed to define key processes, are not explained in detail in the Implementation Plan and few commitments were forthcoming.

The WOCE VOS requirements, in the Indian Ocean, are exactly the same as those of the TOGA Programme. Most lines, see Figure 3, have potential operators but the continual lack of probes hinders full implementation, in spite of the fact that TOGA has been in operation since 1985.

The sea level network in the Indian Ocean has expanded steadily over the past five years, some sites having satellite reporting capabilities, as a result of TOGA initiatives. Several of these existing sites would be prime candidates for the WOCE comprehensive sea level data set and possibly for the rapid delivery data set. Sites appropriate for WOCE need to be identified and the agreement of the operators to meet WOCE specifications sought.

Six of the twelve current meter mooring arrays in the Indian Ocean are tentatively spoken for, with a major gap in the network along the East African Coast. The mid-ocean and eastern moorings are fairly well accounted for and the situation could even be better were the three potential operators for one site to agree to shift some of their efforts elsewhere.

3 Core Project 2

The Working Group, chaired by Professor W. de Ruijter, agreed that the main themes and basic questions as formulated in the Implementation Plan form a sound basis for meeting WOCE goals in the Southern Ocean.

It was suggested that more planning is required to determine whether the fluxes of heat and salt (rather than just total volume) could be determined at the three Choke Point sections. While most of the MW lines were subscribed to, there needs to be some further assessment as to whether the tracer measuring capability is adequate. In addition, there needs to be some co-ordination to get the Choke Point sections and the "30°S" heat flux sections completed within one year (season).

With respect to the eddy energy moorings, there was a large mismatch between the requirements and the resources. It was suggested that single moorings (rather than arrays) would make better use of the resources. The Core Project 2 Working Group needs to reassess the locations and the priority of the eddy energy moorings. In this reassessment, the possibility of deploying the moorings from WHP or other cruises needs to be considered.

It was noted that there may be other means for determining the poleward eddy heat flux, for example, using Batfish (or XBT) measurements and ADCP data.

There is a clear need for pressure sensors on a proportion of the Southern Ocean drifters.

There are quite a few non-WOCE oceanographic and sea ice activities taking place. These need to be co-ordinated with WOCE.

Pressure gauge measurements of sea level are being completed at a number of the Southern Ocean Islands but there are few measurements of sea level in Antarctica. Sea level measurements are still required along the Choke Point sections.

4 Core Project 3

The Working Group met under the chairmanship of Dr W.J. Gould and assessed the level of resources identified by the observational working groups which would contribute to achieving the goals of Core Project 3, namely: "to study the processes that must be better understood if decadal climate predictions using models are to be made by the end of WOCE". The Implementation Plan provides a strategy to meet this objective that involves measurements in the Atlantic at scales from those of the basin to those of more traditional process studies.

The Group was encouraged that there was interest in carrying out a number of process studies. These include an Ekman Layer and Subduction Experiment as well as the Tracer Release Experiment to measure diffusivity. On the larger scale, the Deep Basin Experiment seems assured with the expressions of interest from several nations. However, a key element of Core Project 3 involves the use of repeated hydrographic surveys and a set of five "Control Volumes" in the North Atlantic to study the changes in gyre strength and shape over a 1 year period. Although interest was expressed by Canada and UK in occupying Control Volumes, not all were subscribed. In addition, the Implementation Plan calls for better temporal coverage in the Atlantic and it was noted that the shortfall of shiptime allocated to repeated hydrography as identified by the WHP Working Group was greatest in the Atlantic (400 days) or 50% of the total. This could possibly be alleviated by contributions from the USSR which expressed particular interest in Core Project 3. The Implementation Plan calls for enhanced basin-scale measurements by floats and surface drifters which were also not fully subscribed at the Conference.

The Group observed that these gaps in resources could mean that some of the larger-scale aspects of the Core Project 3 might not be achieved. These are essential for providing data for the development and testing of gyre-scale models.

The Group was unable to make a full assessment of resources in the time available but was concerned that there was a major shortfall (identified above) that would jeopardise the full achievement of Core Project 3 goals. It was therefore recommended that the IPO, in consultation with necessary experts, make a full assessment of commitments to Core Project 3 and if necessary that the SSG convene a meeting of the Core Project 3 Working Group and other experts to discuss the Core Project and devise means by which its objectives might be achieved.

CONCLUSIONS AND RECOMMENDATIONS FROM THE CONFERENCE

1 Introduction

The last session of the conference was led by Dr J. Baker who thanked the Conference Chairman, Professor G. Siedler, and all the participants for their contributions to the Conference. He noted that it is only through the contributions of individual scientists and organizations that programmes like WOCE can be successful. Secondly, he thanked all those who helped in the preparation of this summary, particularly Dr J. Woods and the other members of the WOCE SSC.

Dr Baker stated that although the session was the last of the conference, what was said during the Conference was far from the last word on WOCE. Rather, it was the beginning of the implementation of what could be the most exciting scientific programme ever carried out in oceanography. WOCE will bring us closer to understanding the ocean on global scales - a dream of oceanographers for many decades. At the same time, if we as a community are successful we will be, as Professor Wunsch stated in his opening remarks, far closer to understanding the role of the ocean in climate.

From the beginning of the WCRP, there has been a general recognition that understanding the ocean and its interaction with the atmosphere is key to understanding climate change. The TOGA programme has focused on interannual climate variability. At the same time, there has been a recognition that the global ocean is a fundamental element of climate change on time scales from interannual to decadal and longer. To understand how the global ocean interacts with the atmosphere, we must first look to describing and understanding the general circulation of the ocean. This is the goal of WOCE. Thus TOGA and WOCE together form the essential ocean components of the WCRP.

One of the most likely effects of climate change in the coming decades is a rise of sea level, which will have a direct social and economic impact on the large populations living near the sea. Thus coastal states will be the first beneficiaries of improved predictions of the rate of global climate change. Such predictions can only come through a successful WOCE.

Other programmes related to climate and global environmental change will interact closely with WOCE. WOCE will look to TOGA for certain key measurements in the tropical regions. The Joint Global Ocean Flux Study (JGOFS) which will focus on study of biogeochemical cycles and their impact on global change will look to WOCE for the basic understanding of the general circulation. JGOFS will carry out a global programme of oceanic CO_2 measurement together as part of the WOCE Hydrographic Programme. As we look to the future, it is clear that the developing International Geosphere-Biosphere Programme must build on the understanding of the global ocean that will be provided by WOCE. As a consequence of all of this, we can see that a successful WOCE will address critical societal problems.

The central issue that we have discussed is the question of whether there are adequate resources for carrying out WOCE as defined by the WOCE Scientific Plan and the WOCE Implementation Plan. And we have found that for most parts of the plan the answer is yes, and in some parts the proposed resources actually exceed expectation. From its earliest conception, WOCE planning depended upon the availability of resources to mount a truly global experiment. Thus this positive result is good news. At the same time we note caution in that much effort will be required to make sure that these potential resources are actually made available.

In the course of discussing the major question of national contributions and resources, the Conference programme has ranged over a wide variety of subjects, from the importance of the role of the ocean in climate to the details of implementation and organizational arrangements. There has been a sense of urgency for moving ahead. There has been positive and general support for the scientific elements of the plan, and national planning shows that the necessary resources are mostly in place. Organizational arrangements have been discussed. As in all such Conferences, there has not been unanimous agreement on all points, but all parties have had an opportunity to raise issues of concern. Now we are ready to proceed.

2 Conclusions of the Conference

The Conference reached a consensus on a number of conclusions and recommendations. The Conference also noted a number of specific issues that must be addressed by the WOCE SSG, its parent bodies, and its affiliated bodies as appropriate. These issues were discussed at length in the Working Group meetings. This section summarizes and provides the consensus viewpoint of the conference as a whole. The general findings were:

The Conference finds that WOCE science is exciting, of global scale, and of global interest. It is relevant and urgent. Until the objectives of WOCE are achieved it will be impossible to make reliable predictions of climate.

The Conference agrees that the WOCE Scientific Plan defines the science goals and objectives for a focused global programme that addresses the major WOCE science issues. The plan has been developed by oceanographers representing the broad international community.

The Conference agrees that the WOCE Implementation Plan is a well-considered and practical approach to the achievement of WOCE goals. The Implementation Plan provides a context and framework for the optimum development of WOCE. The plan will evolve in a way consistent

with the available resources. The data set specified in the Implementation Plan is both necessary and sufficient for achievement of the WOCE objectives.

The Conference notes that there is room in the plan for contributions of all kinds from all countries at all technical levels. Thus there is a role for all interested countries who can participate. The Conference notes and is encouraged by the fact that access to WOCE data has been considered carefully in the Implementation Plan, and that all WOCE participants are to have access to WOCE data as provided by the data sharing policy in the Plan. The Conference expressed concern that practical ways for achieving this goal be studied.

The statements by Conference participants have shown that the presently committed and potentially available resources in national plans are sufficient to justify the start of the field phase of WOCE in 1990. The Conference was pleased to see that the proposals made for the WOCE Hydrographic Programme and the direct current measurements are sufficient to meet the global coverage goals of Core Project 1 and Core Project 2. The Conference was also pleased to see proposed additions to the Implementation Plan in the polar and equatorial regions. There appears to be a good match between global coverage needs and the ability of nations to provide the necessary resources. This new data set will be a major milestone in the progress of oceanography. Because of the need for a consistent data set, the Conference urges all participants to adhere to the WOCE standards and to measure the necessary set of parameters.

The Conference was also pleased to see that the potential is good for global coverage of surface layer measurements, including XBTs and surface drifters. The satellite coverage of global surface winds and surface topography for geostrophic currents is now in place with the on-schedule development of ERS-1 and TOPEX/POSEIDON. The global sea level programme appears to be well on track.

The Conference notes that loss of any of the major contributions could lead to critical gaps in the WOCE data set Continued strong national efforts are necessary to ensure adequate implementation and a balanced programme.

The Conference notes that critical gaps still exist in the areas of commitment to satellite wind measurements after ERS-1, improved meteorological measurements for estimates of air-sea fluxes, repeat hydrography in certain areas for Core Project 1, control volume measurements and repeat hydrography for Core Project 3 in the Atlantic, a continuing data information unit, current meter or other techniques for eddy statistics in the Southern Ocean, and global geoid measurements by satellite for determining geostrophic velocity from altimetry.

If these gaps are not filled, then the SSG, the IPO, and the national planning groups will have to look again at the Implementation Plan and, if necessary, make a reduction in the objectives of certain elements and scope of the experiment.

The Conference emphasizes that satellite-borne instrumentation is a key element of WOCE. This instrumentation requires special attention because of the long lead times involved. Of particular concern is the need for continuity and back-up of existing satellites throughout the intensive field phase (1990–1996) of precision altimetry for ocean current measurements and the scatterometer for surface wind measurements and adequate overlap of the various missions.

The first need is for a follow-on to ERS-1 that could also serve as a back-up for that satellite. A second need here is to ensure the flight of the US NASA scatterometer during the WOCE observing period. It has been proposed that the scatterometer be flown on the proposed Japanese Advanced Earth Observation Satellite (ADEOS). The Conference notes the fundamental importance of the flight of the NASA scatterometer and urges the SSG and its parent bodies to make a strong case for WOCE needs to the countries involved.

The Conference also emphasizes that a major goal of WOCE is to formulate a strategy for long-term ocean observations. Without these observations, much of ocean variability indicative of climate change cannot be documented. Immediate action items include decisions on satellite remote sensing instruments for the late 1990s and the support of new technology development for automated in situ systems. Coordination with the IOC TC/OPC and WMO is essential to ensure that WOCE developments are taken into account in planning for operational IOC programmes. It is essential that the membership of the relevant groups, including the TC/OPC, evolve in order to ensure proper representation of WOCE scientific planning and relevant operational ocean observation programmes.

The Conference notes that in order for WOCE to succeed it must have a clearly developed organizational plan. A draft plan for organizational arrangements for WOCE has been proposed by the chairmen of the SSG, the CCCO, and the IOC TC/OPC. The Conference thanks the Chairmen of these groups for their hard work in coming to this statement, but at the same time noted certain points that need clarification, and raised issues of representation that need further discussion. The President of SCOR and the Chairman of IOC are asked to take the points that are raised in the report of the Working Group on Organization into account in the further development of the organizational plans. The Conference notes that it is essential for WOCE to proceed, and that lack of a final decision here should not impede further development of WOCE. It is clear that success in the organizational arrangements will require hard work and good will among all the governmental and non-governmental parties involved.

3 Recommendations and Next Steps

Some recommendations or consensus viewpoints of the Conference were accepted which summarized the general views of participants as well as what has already been done and spelled out in more detail in statements from the Working Groups. The points that were made, in particular the identification of critical gaps in the WOCE programme, will next have to be considered by the WOCE SSG and its parent bodies.

In order to proceed with WOCE, the Conference has found that a number of actions are necessary. These recommendations are made to the WOCE SSG and its parent bodies:

1. The Conference recommends to the WOCE SSG and its parent bodies that the SSG should now proceed, with the assistance of the WOCE IPO, to develop the WOCE programme for a start of the field programme in 1990.
2. The Conference recommends to the WOCE SSG that the WOCE IPO prepare a detailed assessment of resources from the conference proceedings and other information from those not present.
3. The Conference recommends to the WOCE SSG that the Core Project Working Groups continue to advise the SSG, and that they should meet soon in order to assess resources available in the context of the Implementation Plan, and to consider what, if any, adjustments of the plans are required.
4. The Conference recommends to the SSG and its parent bodies that they use all appropriate means to find resources to fill critical gaps.
5. The Conference recommends that the SSG use all appropriate means including its parent bodies to urge all nations to make special efforts to maximize their contribution to WOCE. As part of this effort, the successful WOCE workshops exemplified by the ones in Argentina, Brazil and China should continue.
6. The Conference recommends that the SSG request each nation with an interest in WOCE to identify a representative or national committee that will focus national interest.
7. The Conference recommends that the SSG urge all appropriate organizations to make every effort to quality control all of their routine oceanographic temperature and salinity observations and routine surface meteorological data. Special efforts should be made to see that this data is exchanged as quickly as possible through existing data exchange mechanisms.
8. The Conference recommends that the SSG give special attention to completing the data plan, and that access to WOCE data be assured to all participants in the WOCE programme. 'The Data Information Unit is an important element of the data plan, and resources need to be found to continue it. The Conference recommends that vigorous efforts be made to extract products of use to WOCE from the existing historical data base of relevance and that this data be made available to WOCE participants as provided by the data sharing policy in the Implementation Plan.
9. The Conference notes the fundamental importance of the follow-on satellite to ERS-1 which will also serve as a back-up for that satellite and the flight of the NASA scatterometer on the Japanese ADEOS satellite. It urges the SSG and its parent bodies to use the WOCE goals and needs to make a strong case for these satellite programmes to the countries involved.
10. The Conference recommends that the SSG and its parent bodies make known to coastal states, who will be the principal beneficiaries of the information and understanding to be gained by WOCE, the importance of facilitating access to their territorial seas by foreign ships involved in the WOCE programme.
11. The Conference recommends to the SSG that it continue to ensure that its membership and that of its subgroups includes both strong scientific representation and national planning and implementation.
12. The Conference recommends that the SSG publish an annual assessment of achievements, plans, and gaps remaining, and that this be distributed to its parent bodies and other interested parties.
13. The Conference also recommends that the SSG publish a descriptive brochure on WOCE that describes for the general public the background, plans, and importance of the experiment for understanding and predicting climate change.
14. The Conference recommends that the organizational plan as presented by the chairmen of the SSG, CCCO, and TC/OPC be further developed as appropriate to take into account the discussion at the Conference and that the modified plan then be submitted to the parent bodies for approval.

4 Some Final Points

WOCE planning has involved the efforts of many of the best oceanographers around the world for several years. Much scientific effort has been expended by the SSG, the IPO, and national committees and groups. Now the most interesting part begins with the actual measurements and modelling. But the experiment can be carried out only if resources are forthcoming.

The contributions to the Conference have shown that world resources in oceanography are indeed at least potentially equal to the task of doing a global experiment like WOCE. But as resources are made available, a match must be made between national interests and potential contributions and the context of the WOCE Scientific Plan and the WOCE Implementation Plan.

Each of the opening speakers emphasized the importance and intense interest of the public and governments in climate change and man's influence on the environment. Now it is up to us to show that all nations can be well served by support of WOCE as a fundamental contribution to understanding and predicting the effects of climate change. The proposed popular brochure on WOCE to be prepared by the SSG will help national organizations explain that to understand climate, we need to understand the ocean. This is especially important as we look in the future to programmes of the International Geosphere-Biosphere Programme which seeks to understand the climatic effects of biogeochemical cycles.

The proposed organization plan involves important and significant links with CCCO and the IOC TC/OPC. Whatever final arrangement is established, WOCE will need a strong interaction with the TC/OPC. The success of this interaction is important, not just to WOCE, but to the future of oceanography. Can these organizations respond in an efficient way to provide the help for implementation and to ensure that all nations can participate consistent with their interest and in the context of a scientific plan? The answer will be very important to the future of global oceanography. Are all countries being provided with what they need to participate in WOCE?

As one of the prerequisites for climate prediction, WOCE has much to offer all countries, and in turn WOCE will benefit from the participation of all countries. The aim is to encourage and build strong national programmes in the context of an agreed scientific formulation. Such strong national component programmes are essential if WOCE is to succeed and achieve the planned benefits to the global community. Dr Baker finished his presentation with a point made earlier. There is room in the WOCE Implementation plan for contributions of all kinds from all countries at all technical levels. Thus there is a role for all interested countries who can participate.

WOCE is difficult, but WOCE is technically and financially feasible. The Conference looked forward to maximum contributions to this exciting new programme.

CLOSING

The chairman of the Conference thanked the participants on behalf of the sponsoring organizations for their contributions and help during the Conference. He felt that the Conference had achieved the principal results that were hoped for. WOCE planning had been accelerated in many national organizations in view of the conference, presentations at the Conference had shown that sufficient resources for the experiment can very probably be found, and a broader involvement of oceanographic communities in a large number of countries was achieved. He expressed his thanks to UNESCO and all the parties involved in resolving the problems that had existed during the Conference with respect to the participation of all bonafide scientists in the Conference. Although much remains to be done in the future planning of WOCE, he expressed the hope that the Conference would be remembered as an important and necessary step in the development of the programme.

The chairman thanked UNESCO and its IOC for providing the facilities and technical assistance. He expressed appreciation for the hard work of the secretaries and scientists of the conference staff, and he expressed particular thanks to Mr R. Godin, Secretary CCCO, and Dr G. Needler, Director of the WOCE International Planning Office, for their major contributions to the preparations and conduct of the Conference. The Conference closed at 11:00, 2 December 1988.

WOCE is a component of the World Climate Research Programme (WCRP), which was established by WMO and ICSU, and is carried out in association with IOC and SCOR. The scientific planning and development of WOCE is under the guidance of the JSC/CCCO Scientific Steering Group for WOCE, assisted by the International WOCE Planning Office. JSC and CCCO are the main bodies of WMO-ICSU and IOC-SCOR, respectively for formulating overall WCRP scientific concepts.

The WOCE Newsletter is edited at the WOCE-IPO at IOS, Wormley, Godalming, Surrey, UK by Denise Smythe-Wright. Financial support is provided by the Natural Environment Research Council, UK.

We hope that colleagues will see this Newsletter as a means of reporting work in progress related to the Goals of WOCE as described in the Scientific Plan. The SSG will use it also to report progress of working groups, and of experiment design and of models.

The editor will be pleased to send copies of the Newsletter to Institutes and Research Scientists with an interest in WOCE or related research.